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(54) **SHEET FEEDING APPARATUS**

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B65H 3/44	(2006.01)
B65H 7/02	(2006.01)
B41J 13/00	(2006.01)
B41J 11/04	(2006.01)

(52) **U.S. Cl.**

CPC ***B41J 13/0009*** (2013.01); ***B41J 11/04*** (2013.01)

(58) **Field of Classification Search**

CPC B41J 11/0095; B65H 3/00; B65H 3/0638; B65H 3/0684; B65H 3/44; B65H 2405/3321

USPC 347/104; 271/3.03, 3.14, 3.15, 3.17, 271/9.02, 9.08, 9.09, 21, 117, 164, 165, 271/171, 270, 265.01, 265.02; 400/624

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,920,238	A *	11/1975	Kitajima	G03G 15/6502 271/114
4,577,849	A *	3/1986	Watanabe	B65H 3/44 271/10.13
5,177,547	A	1/1993	Kanemitsu et al.	
5,565,970	A *	10/1996	Suda	G03G 15/6508 271/9.01
5,673,074	A	9/1997	Miyauchi et al.	
5,738,452	A	4/1998	Uchida	
7,857,301	B2 *	12/2010	Samoto	B65H 3/0684 271/9.01
7,883,282	B2 *	2/2011	Izuchi	B41J 3/0018 347/104
7,909,442	B2 *	3/2011	Samoto	B41J 2/17509 347/103
7,959,147	B2 *	6/2011	Izuchi	B65H 3/0669 271/10.03
8,152,167	B2	4/2012	Saito et al.	
8,672,439	B2	3/2014	Suzuki et al.	
8,861,050	B2 *	10/2014	Sahara	H04N 1/00591 271/126
2013/0001856	A1	1/2013	Uchida	
2013/0221597	A1	8/2013	Kotaka	

FOREIGN PATENT DOCUMENTS

JP 2013-180834 A 9/2013

* cited by examiner

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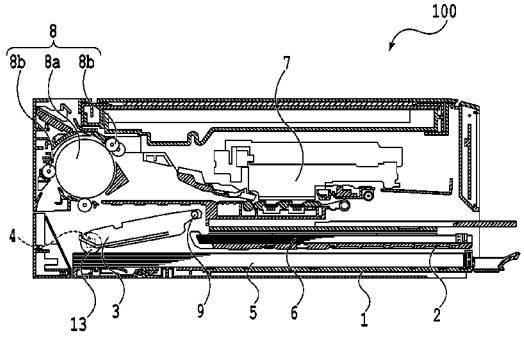
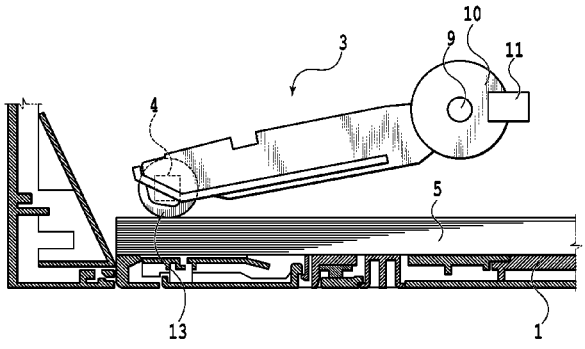
(57) **ABSTRACT**

A sheet feeding apparatus includes: a tray storing a sheet and detachably mounted on an apparatus body; a rotatable arm; a roller, provided on the arm, configured to pick up the sheet on the tray; a sensor, provided on the arm, configured to detect a physical property; and a determination unit configured to determine, based on detection by the sensor, at least any of a mounting state of the tray on the apparatus body and at least one of states of the sheet on the tray selected from the group consisting of the presence or absence of the sheet, a remaining amount of the sheet, a type of the sheet, front and back sides of the sheet, and a size of the sheet stored on the tray.

9 Claims, 12 Drawing Sheets





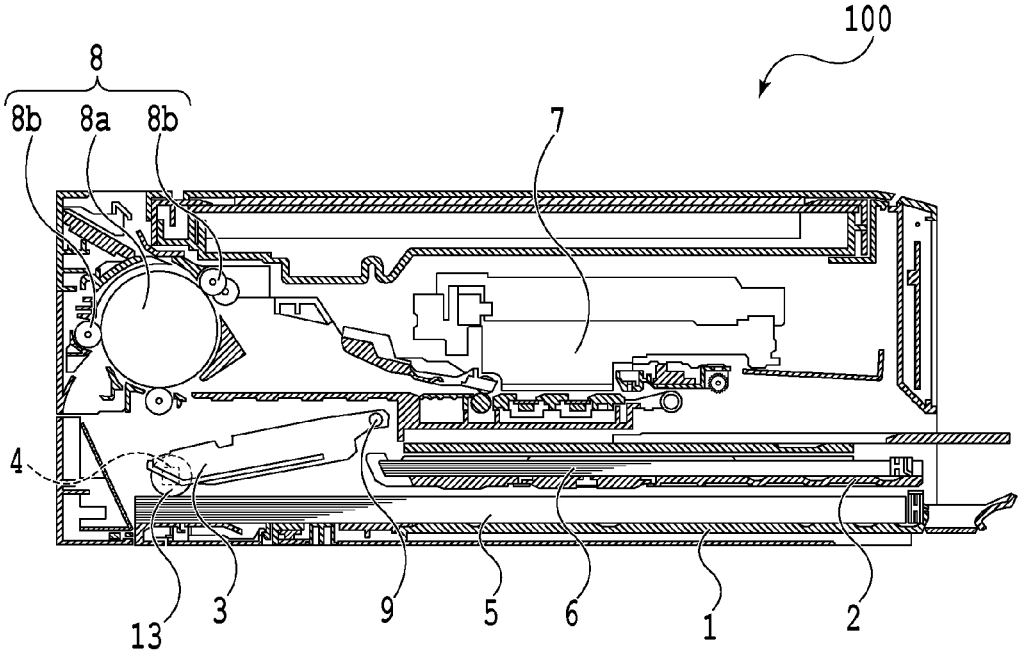


FIG.1A

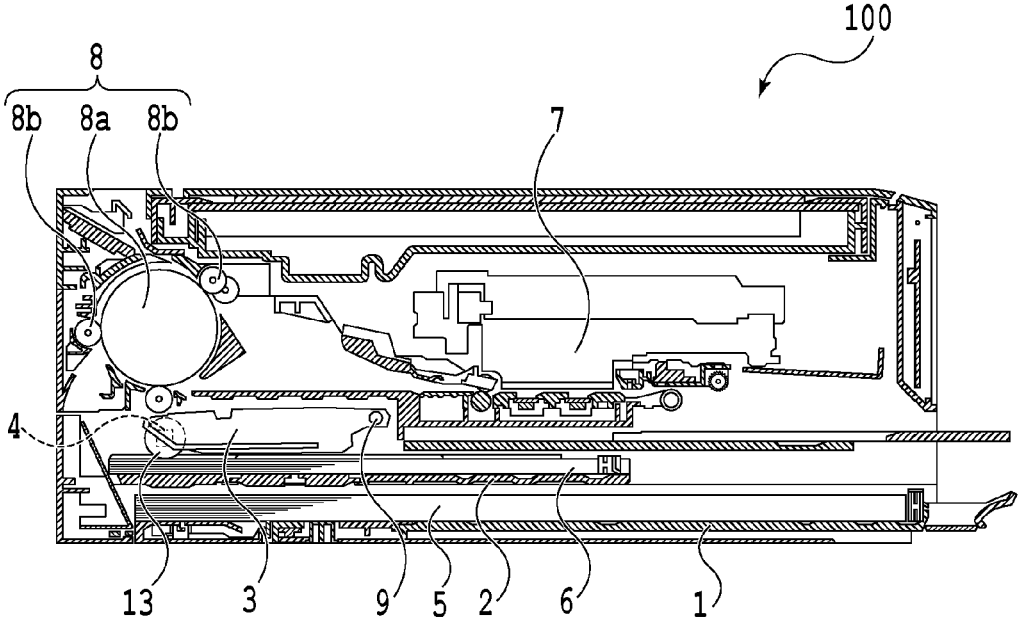


FIG.1B

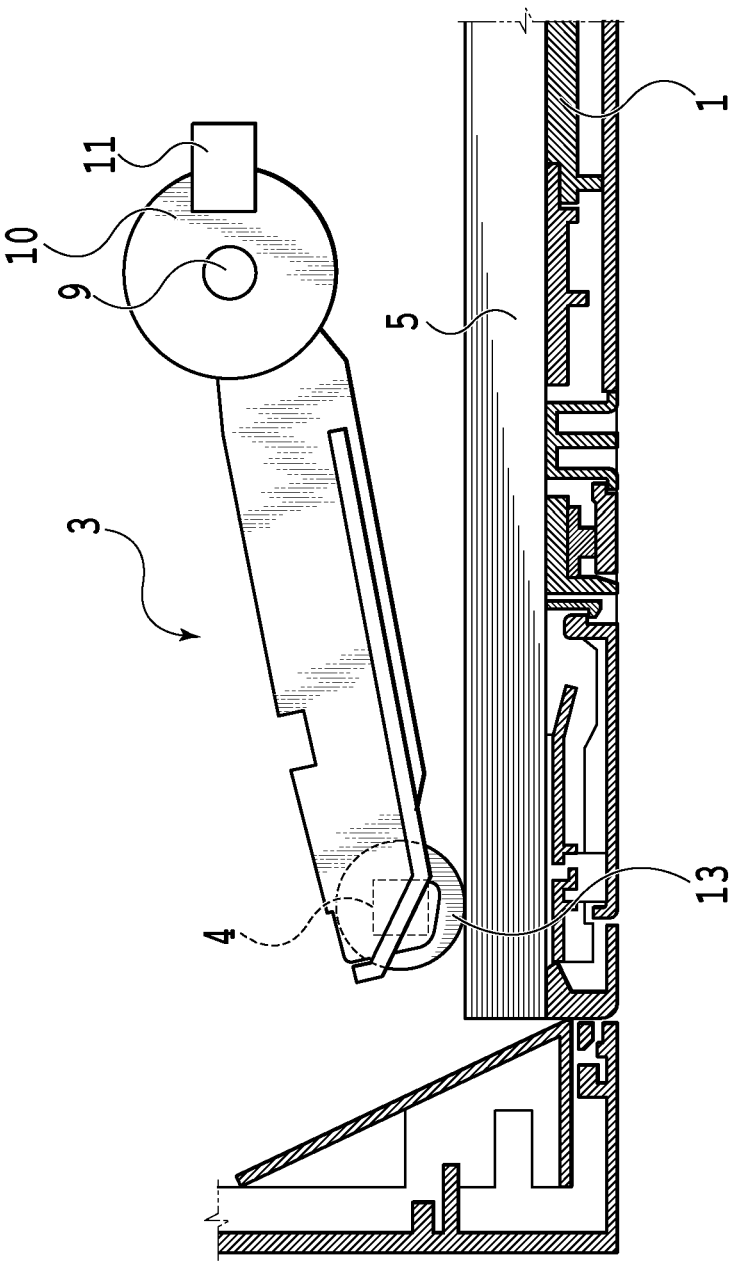


FIG.2

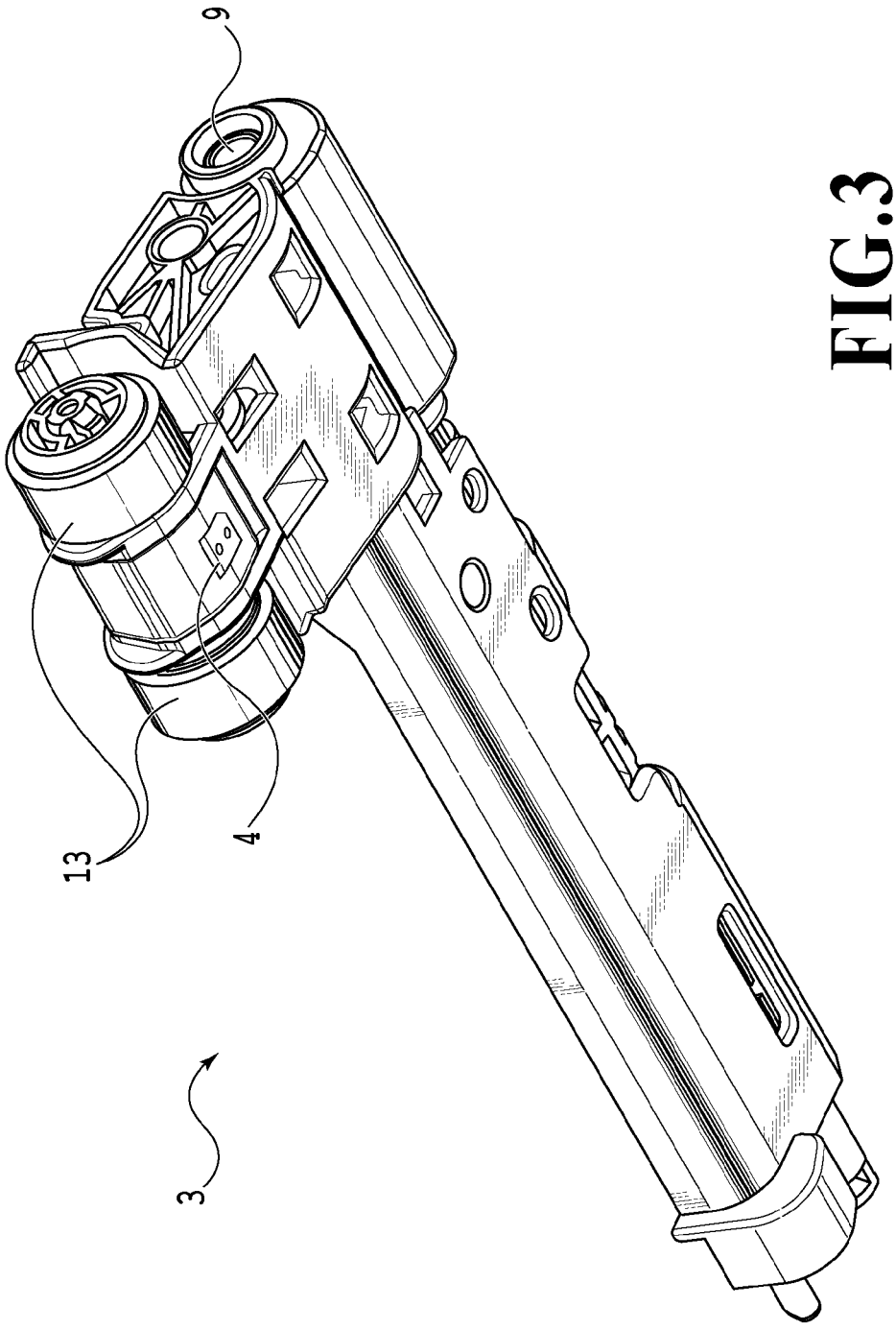
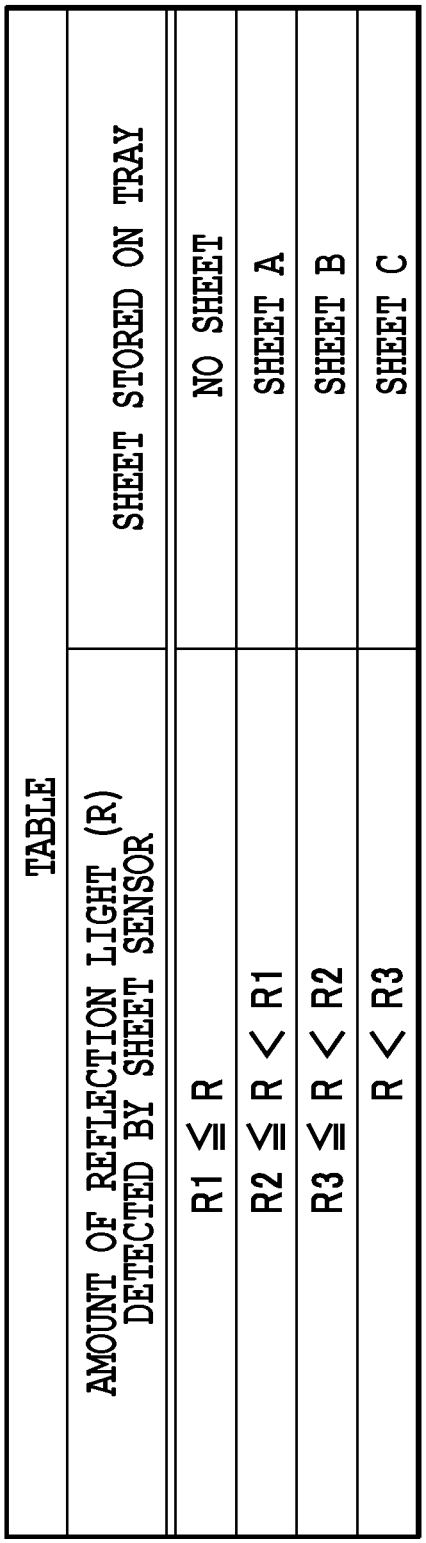


FIG.3



TABLE

AMOUNT OF REFLECTION LIGHT (R) DETECTED BY SHEET SENSOR	SHEET STORED ON TRAY
R1 ≦ R	NO SHEET
R2 ≦ R < R1	SHEET A
R3 ≦ R < R2	SHEET B
R < R3	SHEET C

FIG.4

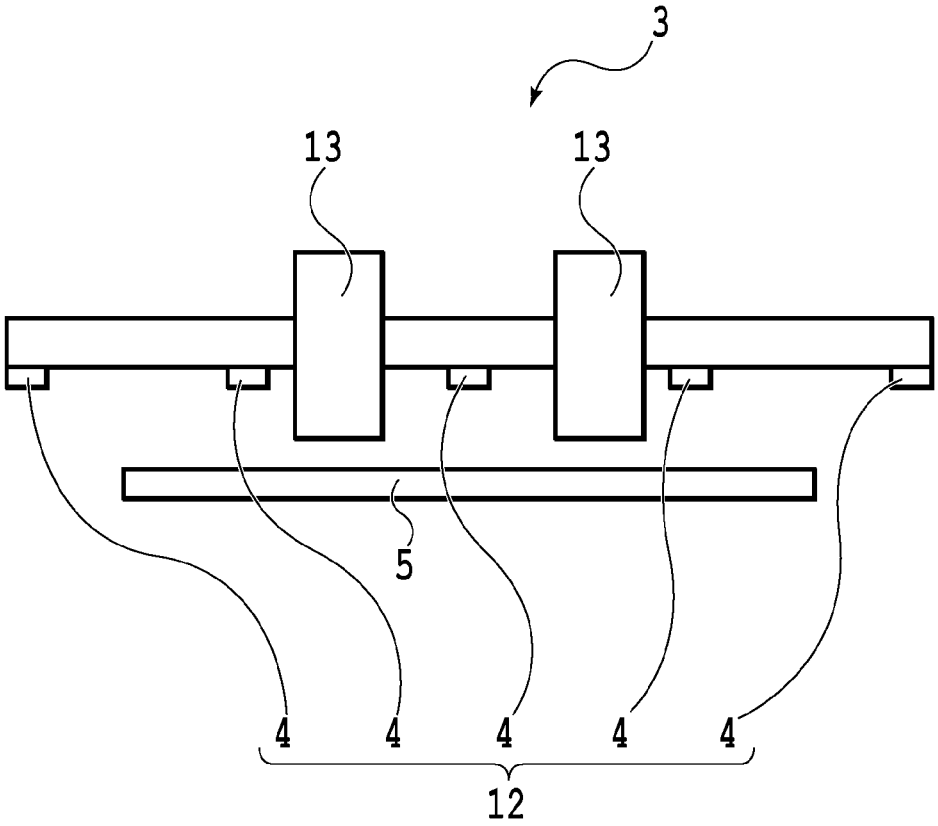


FIG.5

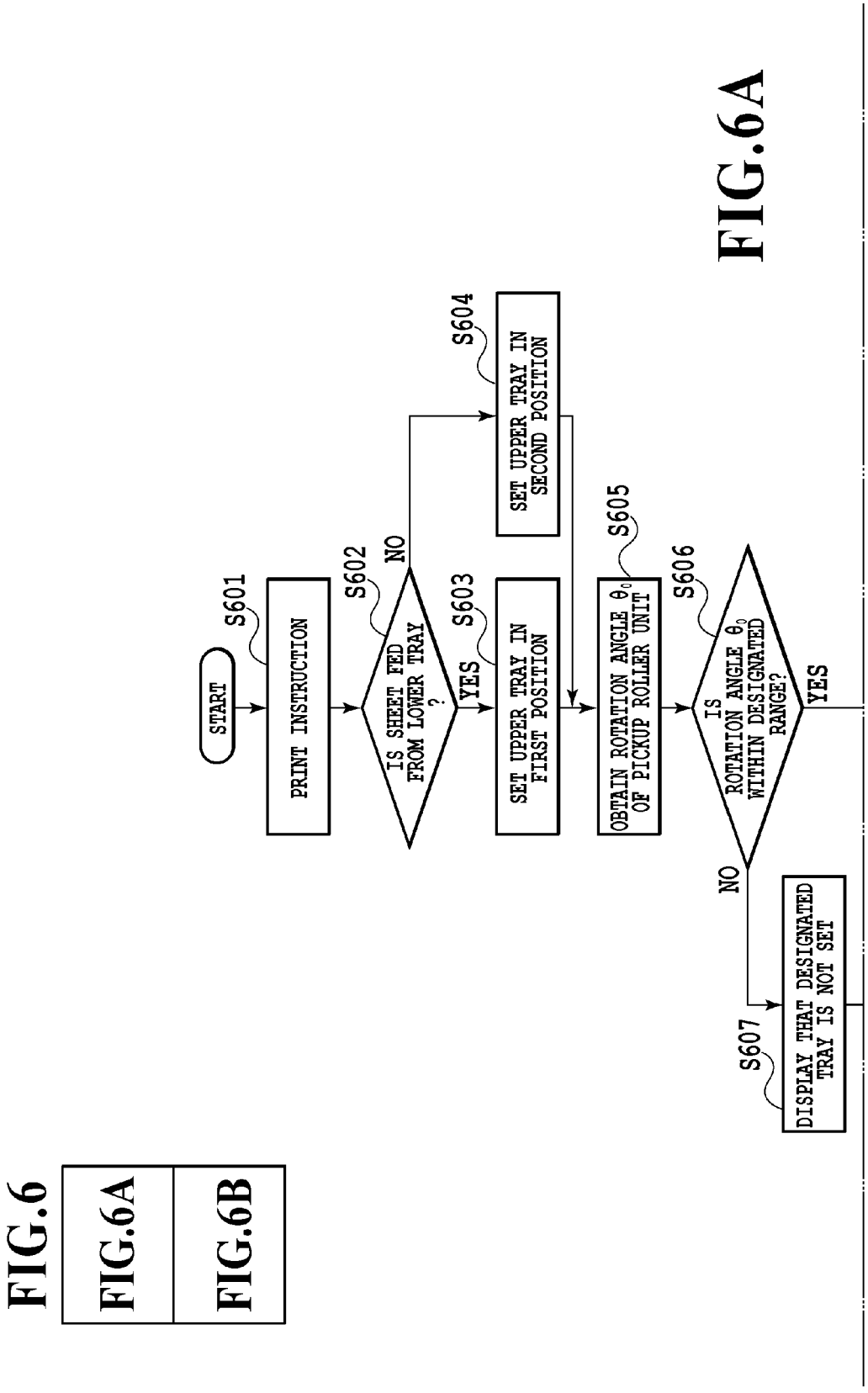


FIG.6A

FIG.6

FIG.6A
FIG.6B

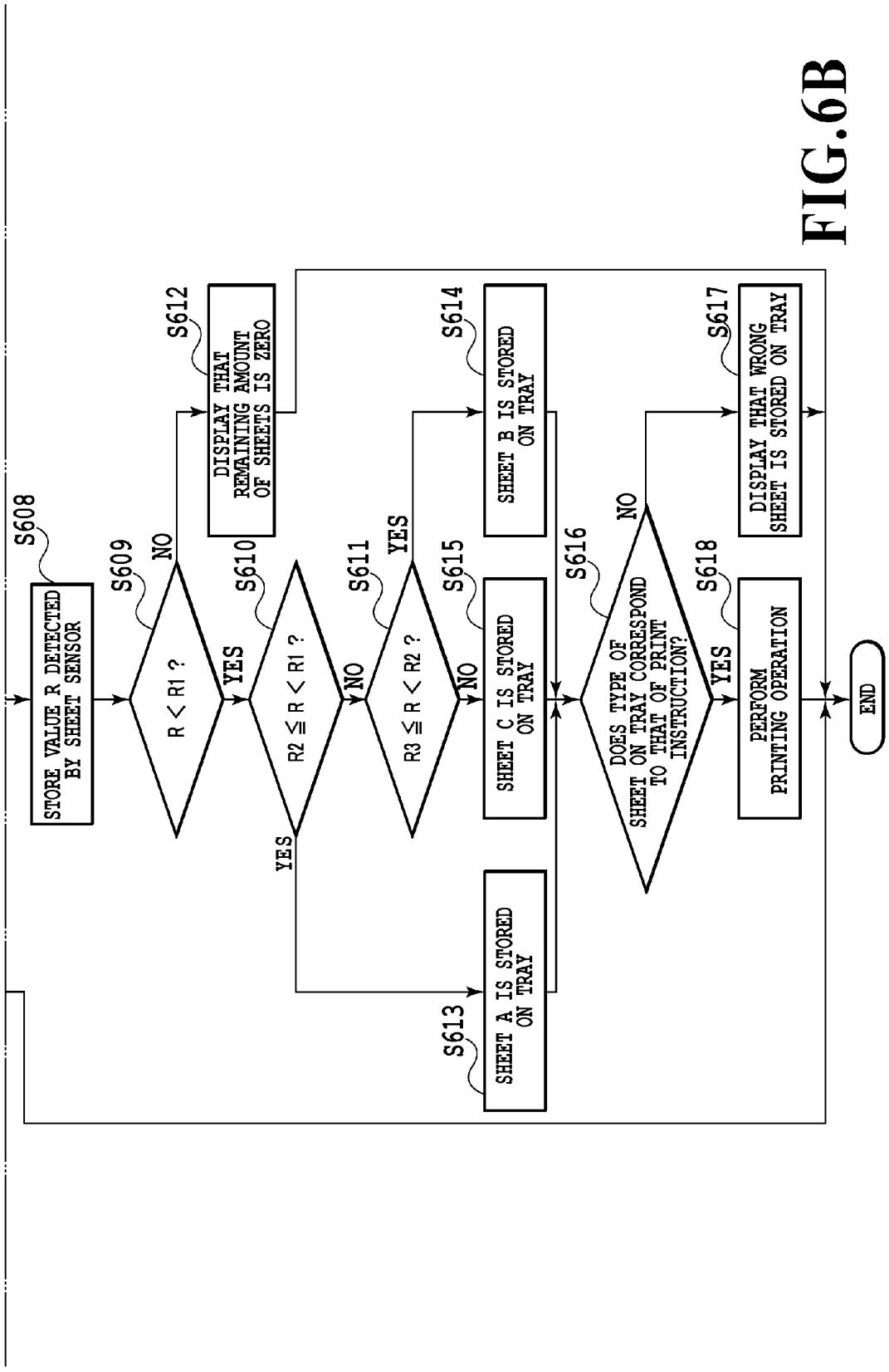

S608
STORE VALUE R DETECTED BY SHEET SENSOR
S609
R < R1 ?
NO
YES
S610
R2 ≦ R < R1 ?
NO
YES
S611
R3 ≦ R < R2 ?
YES
NO
S612
DISPLAY THAT REMAINING AMOUNT OF SHEETS IS ZERO
S613
SHEET A IS STORED ON TRAY
S614
SHEET B IS STORED ON TRAY
S615
SHEET C IS STORED ON TRAY
S616
DOES TYPE OF SHEET ON TRAY CORRESPOND TO THAT OF PRINT INSTRUCTION?
NO
YES
S617
DISPLAY THAT WRONG SHEET IS STORED ON TRAY
S618
PERFORM PRINTING OPERATION
END

FIG.6B

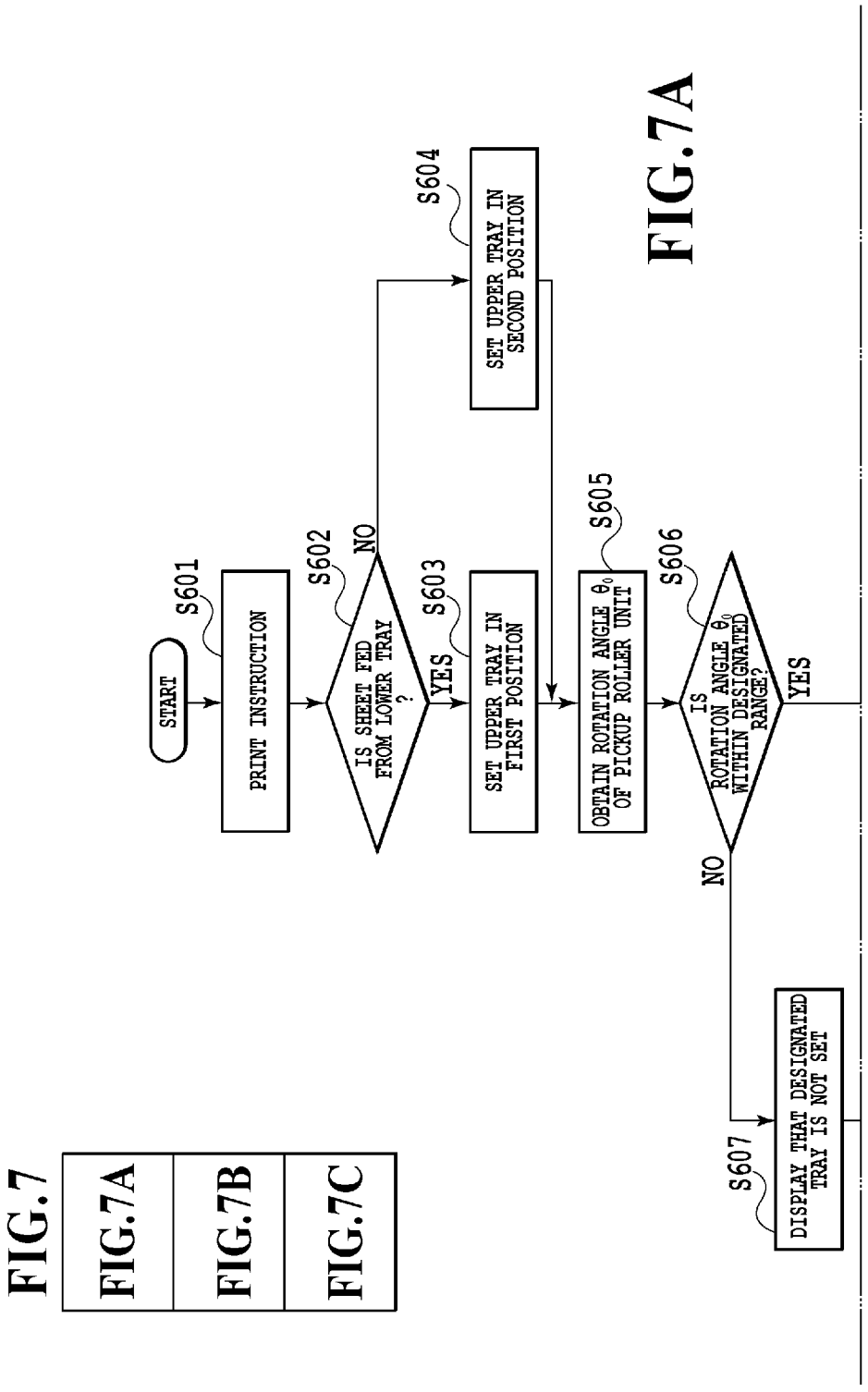


FIG.7A

FIG.7

FIG.7A
FIG.7B
FIG.7C

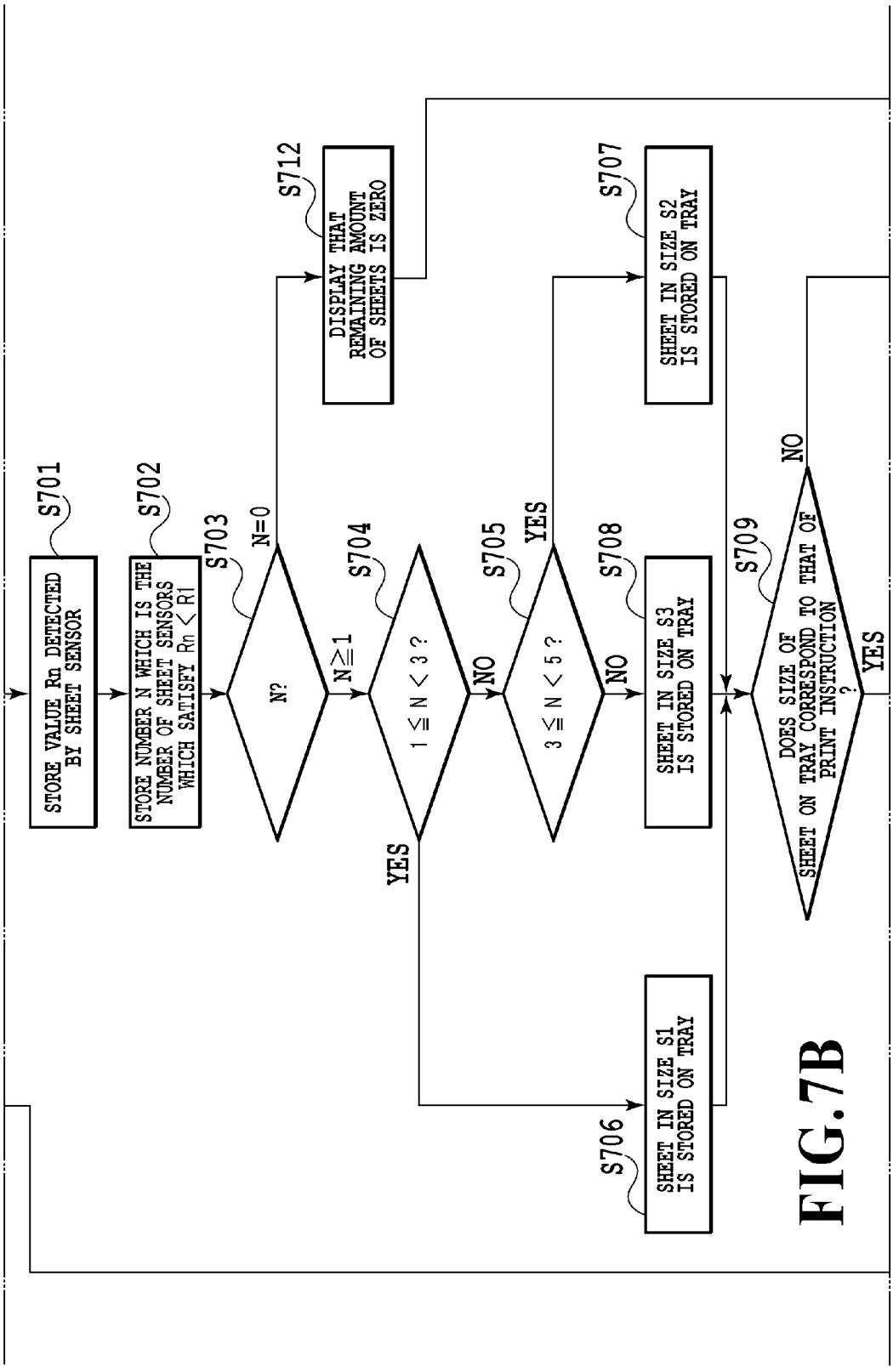

S701
STORE VALUE Rn DETECTED BY SHEET SENSOR
S702
STORE NUMBER N WHICH IS THE NUMBER OF SHEET SENSORS WHICH SATISFY Rn < R1
S703
N?
N=0
N≧1
S712
DISPLAY THAT REMAINING AMOUNT OF SHEETS IS ZERO
S704
1 ≦ N < 3 ?
YES
NO
S705
3 ≦ N < 5 ?
YES
NO
S706
SHEET IN SIZE S1 IS STORED ON TRAY
S707
SHEET IN SIZE S2 IS STORED ON TRAY
S708
SHEET IN SIZE S3 IS STORED ON TRAY
S709
DOES SIZE OF SHEET ON TRAY CORRESPOND TO THAT OF PRINT INSTRUCTION ?
NO
YES

FIG. 7B

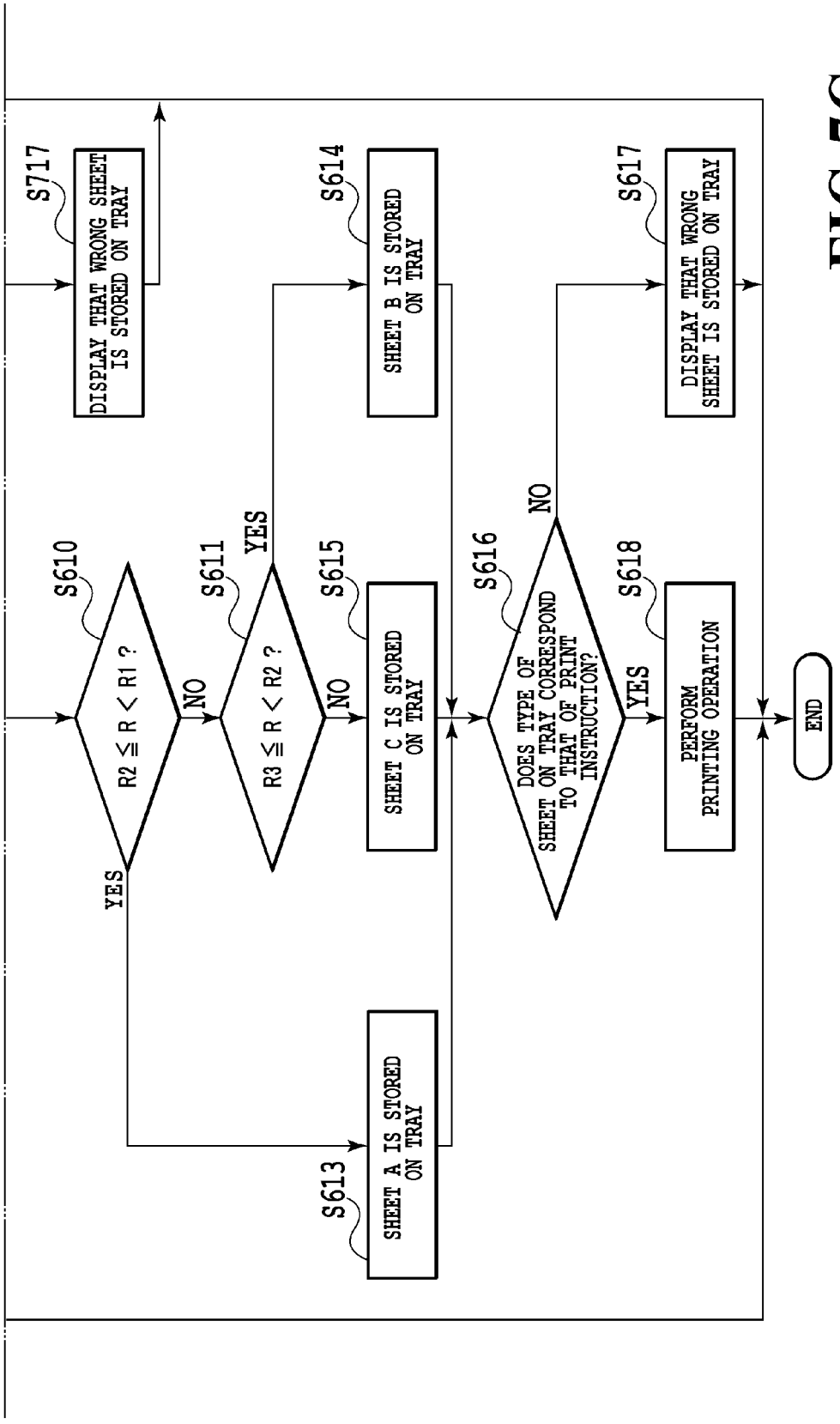

S610
R2 ≦ R < R1 ?
YES
NO
S611
R3 ≦ R < R2 ?
YES
NO
S613
SHEET A IS STORED ON TRAY
S614
SHEET B IS STORED ON TRAY
S615
SHEET C IS STORED ON TRAY
S616
DOES TYPE OF SHEET ON TRAY CORRESPOND TO THAT OF PRINT INSTRUCTION?
NO
YES
S617
DISPLAY THAT WRONG SHEET IS STORED ON TRAY
S618
PERFORM PRINTING OPERATION
S717
DISPLAY THAT WRONG SHEET IS STORED ON TRAY
END

FIG.7C

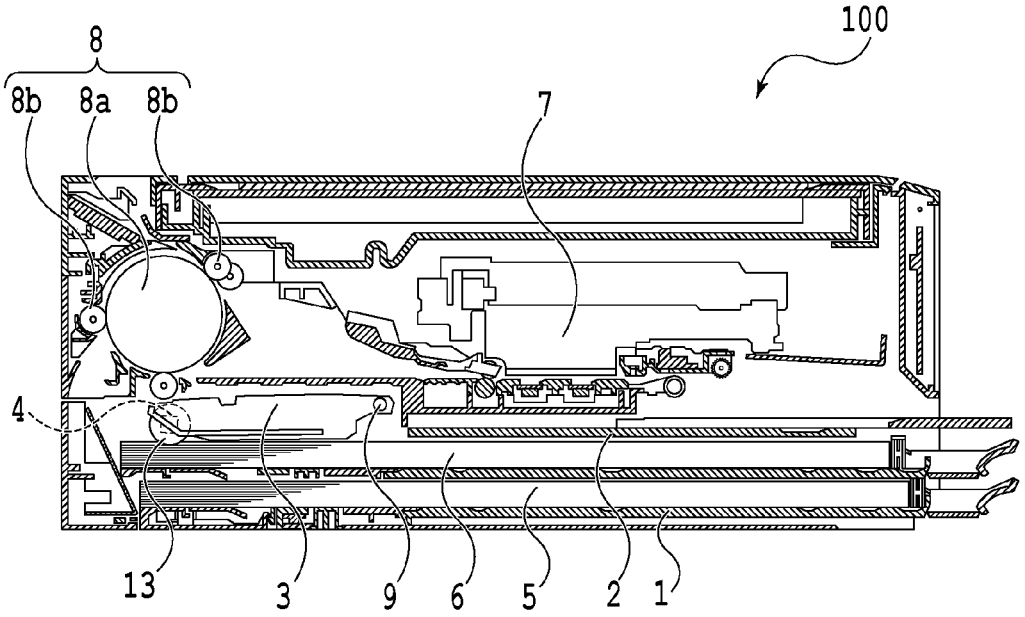


FIG.8

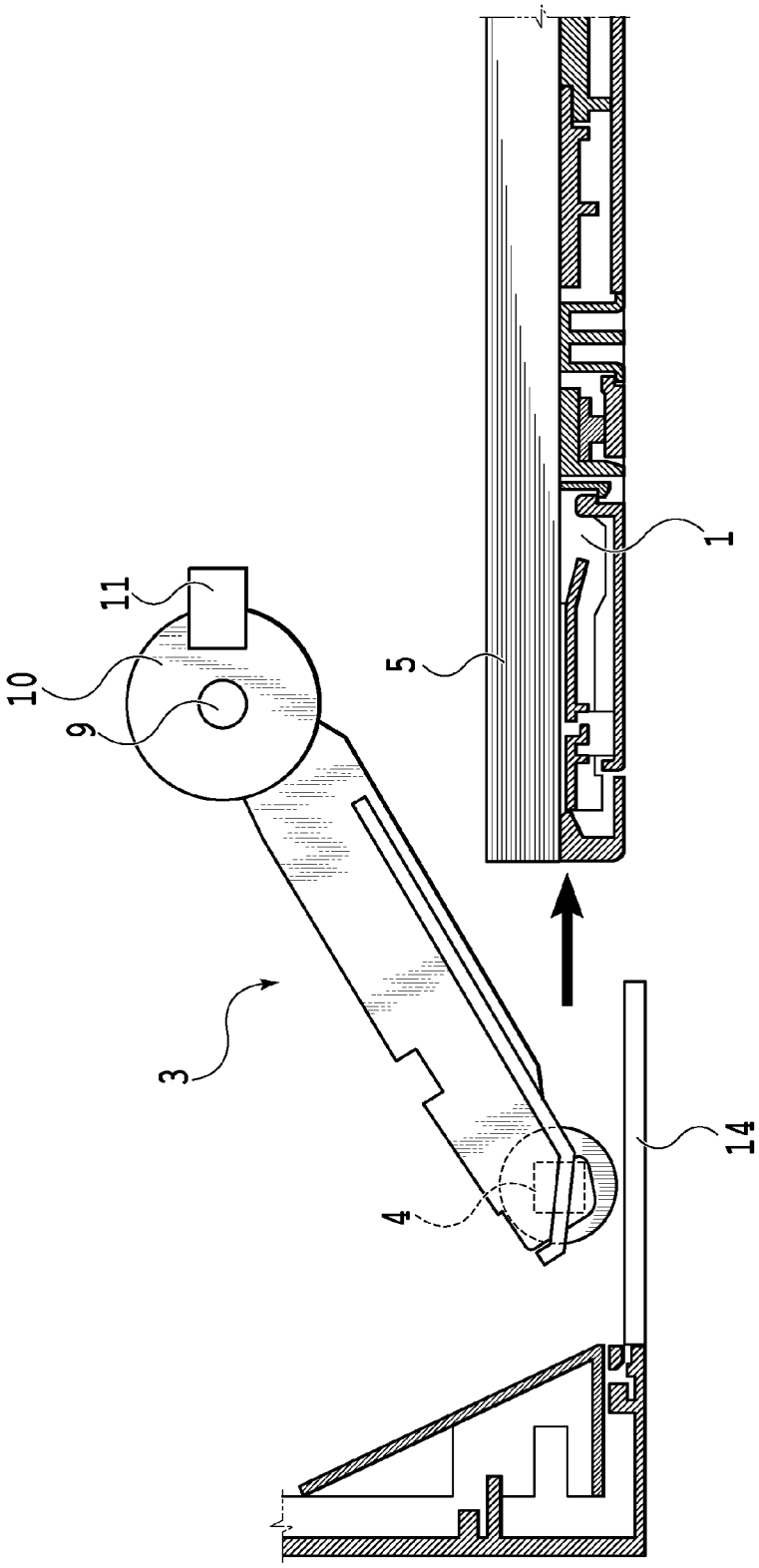


FIG.9

SHEET FEEDING APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a sheet feeding apparatus and a printing apparatus which are capable of detecting the state of a sheet-like medium on a tray.

2. Description of the Related Art

Some printing apparatus have a plurality of housing-type trays on which a sheet-like medium (hereinafter also referred to simply as a sheet) on which printing is performed is loaded. As disclosed in, for example, Japanese Patent Laid-Open No. 2013-180834, some are configured such that two trays in tiers of an upper tray and a lower tray are included, the upper tray being slidable inside a printing apparatus body, and sheets can be fed from both the upper and lower trays by one swing-arm type pickup roller.

SUMMARY OF THE INVENTION

Since a variety of sheets can be retained on a tray, loading mistakenly a wrong type of sheet or a sheet upside down may occasionally cause printing not to be performed in an optimal setting. Further, in a case where printing operation is performed without a sheet being loaded on the tray, the printing operation needs to be reset causing extra work of performing the printing operation again after the sheet is loaded. To avoid such a situation, a technique is required for enabling detection of the state of the sheet on the tray in an early stage prior to performing printing operation. Meanwhile, a large-scale means for detecting the state of the sheet causes the apparatus to be enlarged and thus is undesirable.

An object of the present invention is to provide a sheet feeding apparatus and a printing apparatus which are capable of detecting, in a simple structure, the state of a sheet on a tray.

To solve the above problem, there is provided a sheet feeding apparatus comprising a tray storing a sheet and detachably mounted on an apparatus body; a rotatable arm; a roller, provided on the arm, configured to pick up the sheet on the tray; a sensor, provided on the arm, configured to detect a physical property; and a determination unit configured to determine, based on detection by the sensor, at least any of a mounting state of the tray on the apparatus body and at least any of a mounting state of the tray on the apparatus body and at least one of states of the sheet on the tray selected from the group consisting of the presence or absence of the sheet, a remaining amount of the sheet, a type of the sheet, front and back sides of the sheet (that is, which of the front and back sides of the sheet is faced up), and a size of the sheet stored on the tray.

Further features of the present invention will become apparent from the following description of exemplary embodiments (with reference to the attached drawings).

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1**A and **1**B are cross-sectional views of a printing apparatus according to a first embodiment;

FIG. **2** is a view showing an example of a configuration of a pickup roller unit according to the first embodiment;

FIG. **3** is a view showing an example of an arrangement of a sheet sensor on the pickup roller unit according to the first embodiment;

FIG. **4** is an example of a table showing a correlation between the amount of reflection light which is detected by the sheet sensor and the type of sheet according to the first embodiment;

FIG. **5** is a front view showing an example of a configuration of a pickup roller unit having a plurality of sheet sensors according to a second embodiment;

FIG. **6** is a diagram showing the relationship between FIGS. **6**A and **6**B;

FIGS. **6**A and **6**B show an example of operation sequence from detection of the state of a sheet on a tray to performing printing operation according to the first embodiment;

FIG. **7** is a diagram showing the relationship among FIGS. **7**A, **7**B, and **7**C;

FIGS. **7**A, **7**B, and **7**C show an example of operation sequence from detection of the size of a sheet on a tray to performing printing operation according to a third embodiment;

FIG. **8** is a view showing an example of a configuration in which an upper tray and a lower tray are the same in size; and

FIG. **9** is a view showing an example of a configuration in which presence or absence of the tray is detected by means of a reflector according to the second embodiment.

DESCRIPTION OF THE EMBODIMENTS

Embodiments according to the present invention will be specifically explained below with reference to the drawings. Identical or similar reference numerals denote identical or similar configurations throughout the drawings.

(Configuration of Printing Apparatus)

FIGS. **1**A and **1**B are cross-sectional views of a printing apparatus **100** according to a first embodiment of the present invention. The printing apparatus **100** has a printing unit **7** for printing characters and images on a sheet-like medium (hereinafter also referred to simply as a sheet), a conveying unit for conveying a sheet to the printing unit **7**, and a sheet feeding unit for feeding, to the conveying unit, the sheet to be conveyed by the conveying unit. The printing apparatus **100** further has a control substrate (controller) for controlling operations of driving units.

The printing unit **7** may be configured such that significant information such as characters and graphics, and both significant and insignificant images, designs, patterns, and the like can be formed on the sheet-like medium, and the printing system is not specifically limited.

The printing unit **7**, for example, may be configured to eject liquid (ink) on the sheet by employing an ink jet system. Further, the sheet-like medium, made of/from any material or in any form, on which printing is performed by the printing unit **7**, may be used, as long as the medium is a sheet-like medium on which characters, images, and the like can be printed, including paper, cloth, a plastic sheet, an OHP sheet, and an envelope.

The conveying unit has a plurality of conveyance roller pairs **8**, each having a conveyance roller **8***a* for conveying the sheet by rotation and a driven roller **8***b* which is driven and rotated in association with the conveyance roller **8***a*. The sheet fed from the sheet feeding unit is conveyed to the printing unit **7** by being sandwiched between the rollers of the conveyance roller pairs **8**.

The sheet feeding unit has two trays in tiers of an upper tray and a lower tray, whose sheet loading surfaces are loaded with and store sheets on which printing is to be performed by the printing unit **7**, the two trays in tiers being detachably mounted on a printing apparatus body, and a pickup roller unit **3** which picks one sheet out of the trays. The tray may be called a cassette.

The pickup roller unit **3** has an arm rotatably mounted on a rotation support unit **9** and a pickup roller **13** which is rotat-

ably provided on a free end of the arm and which feeds the sheet in contact by picking it up by rotation.

As shown in FIG. **2**, the pickup roller unit **3** has a detector (rotation angle sensor) which moves in association with the rotation of the arm, the detector having an optical scale **10** and an optical encoder **11**, and is capable of detecting its own rotation angle as the state of the rotation. Further, the pickup roller unit **3** is provided with a sheet sensor **4** capable of detecting the state of the sheet.

As the sheet sensor **4**, any of known sensors which allow the sheet to be determined by a physical property detected by the sensor may be employed. In this example, the sheet sensor **4** is a photoelectric sensor having a light irradiating unit and a light receiving unit, wherein a surface to be detected is irradiated with light from the light irradiating unit and reflection light from the surface to be detected is received at the light receiving unit, thereby enabling measurement of an amount of reflection light. The pickup roller unit **3** is configured such that the sheet sensor **4** can detect the physical property of the surface to be detected in a posture in which the pickup roller **13** has been brought into contact with the surface to be detected. The position of the sheet sensor **4** to be mounted on the pickup roller unit **3** is preferably, but not limited to, between a plurality of pickup rollers **13** or near the pickup roller **13** as shown in, for example, FIG. **3**. This is because in a detecting posture, the distance between the sheet sensor **4** and the surface to be detected is small, thereby enabling detection with high precision.

Refer back to FIGS. **1**A and **1**B. Of the two trays in tiers of the upper tray and the lower tray, a lower tray **1** and an upper tray **2** thereabove store Sheet **5** and Sheet **6**, respectively. The upper tray **2** is configured to be slidable, by means of a driving source (not shown), between a first position as shown in FIG. **1**A and a second position as shown in FIG. **1**B inside the printing apparatus body. The control substrate can determine that in a case where the upper tray **2** is set in the first position, the sheet can be fed from the lower tray **1** and that in a case where the upper tray **2** is set in the second position, the sheet can be fed from the upper tray **2**.

(Operation Sequence of Printing Apparatus)

Next, with reference to a flowchart shown in FIGS. **6**A and **6**B, an operation sequence of the printing apparatus **100** from detection of the state of the sheet on the tray to starting printing operation will be explained.

Referring to FIG. **6**A, once a print instruction is issued in step S**601**, it is determined which of the two trays in tiers of the upper tray and the lower tray is designated by the print instruction to feed the sheet. In a case where the sheet is to be fed from the lower tray **1**, the process proceeds to step S**603**, and in a case where the sheet is to be fed from the upper tray **2**, the process proceeds to step S**604**.

In step S**603**, the upper tray **2** is set in the first position shown in FIG. **1**A and the pickup roller **13** of the pickup roller unit **3** contacts the top surface of the lower tray **1**. On the other hand, in step S**604**, the upper tray **2** is set in the second position shown in FIG. **1**B and the pickup roller **13** of the pickup roller unit **3** contacts the top surface of the upper tray **2**. In the present specification, the top surface of the tray means the upper surface of a sheet at the top of the sheets loaded on the sheet loading surface of the tray in a case where the sheets are stored on the tray, and means the sheet loading surface of the tray in a case where no sheet is stored on the tray.

((Detection of Presence or Absence of Tray))

Next, in step S**605**, a rotation angle θ_0 from a reference posture of the pickup roller unit **3** at the time when the pickup roller **13** contacts the top surface of the tray in step S**603** or S**604** is obtained to be stored in a memory of the control substrate.

A rotation angle θ_1 from the reference posture of the pickup roller unit **3** at the time when the pickup roller **13** contacts the top surface of the lower tray **1** with no sheet stored on the lower tray **1** is prerecorded in the control substrate. Similarly, a rotation angle θ_2 from the reference posture of the pickup roller unit **3** at the time when the pickup roller **13** contacts the top surface of the upper tray **2** with no sheet stored on the upper tray **2** is prerecorded in the control substrate.

For convenience of explanation, a case where the pickup roller **13** contacts the top surface of the lower tray **1**, that is, a case where the process proceeds to step S**605** through steps S**602** and S**603** will be described below.

In step S**606**, the rotation angle θ_0 obtained in step S**605** is compared with the rotation angle θ_1 recorded in the control substrate. In a case where the size relation of the rotation angles satisfies $\theta_0>\theta_1$, it is determined that the lower tray **1** is not set in a predetermined position, and the process proceeds to step S**607**. In step S**607**, an interface (not shown) displays that the tray designated by a print instruction is not mounted on the printing apparatus body and the operation sequence ends. On the other hand, in a case where the size relation of the rotation angles satisfies $\theta_0\leq\theta_1$, it is determined that the lower tray **1** is set in the predetermined position and the process proceeds to step S**608** shown in FIG. **6**B.

((Detection of Presence or Absence of Sheet, Type of Sheet, and Front and Back Sides of Sheet))

Referring to FIG. **6**B, in step S**608**, the sheet sensor **4** detects the state of the sheet on the lower tray **1**. Detection of the state of the sheet on the tray can be performed as explained below.

FIG. **4** is an example of a table showing a correlation between the range of values of an amount of reflection light R obtained in a case where the sheet sensor **4** performs detection operation and the type of sheet stored on the tray. For example, in a case where an obtained value of the amount of the reflection light R is R**3** or more and less than R**2**, according to the correlation shown in the table, the type of sheet stored on the tray is determined to be Sheet B. This type of table is prepared for each of the trays and is prerecorded in the control substrate.

Referring back to FIG. **6**B, in step S**608**, the sheet sensor **4** performs operation of detecting the amount of the reflection light in a posture in which the pickup roller **13** contacts the top surface of the lower tray **1**, and the detected amount of the reflection light R is stored in the memory of the control substrate.

Next, in steps S**609** to S**611**, the detected amount of the reflection light R is compared with data recorded in the table, thereby enabling the determination of the presence or absence or type of sheet stored on the tray.

The explanation will be made in more detail. In step S**609**, in a case where the detected amount of the reflection light R is a first threshold R**1** defining a range of the amount of reflection light recorded in the table or higher (that is, R≥R**1**), the process proceeds to step S**612**. In step S**612**, it is determined that no sheet is stored on the tray and the interface (not shown) displays that the remaining amount of sheets is zero, and the operation sequence ends. On the other hand, in a case where the amount of the reflection light R is less than the first threshold R**1** (that is, R<R**1**), the process proceeds to step S**610**.

In step S**610**, further, in a case where the detected amount of the reflection light R is a second threshold R**2** defining a range of the amount of the reflection light recorded in the

table or higher (that is, R2≤R<R1), the process proceeds to step S613. In step S613, it is determined that Sheet A is stored on the lower tray 1, and the process then proceeds to step S616. On the other hand, in a case where the amount of the reflection light R is less than the second threshold R2 (that is, R<R2), the step proceeds to step S611.

In step S611, further, in a case where the amount of the reflection light R is a third threshold R3 defining a range of the amount of the reflection light recorded in the table or higher (that is, R3≤R<R2), the process proceeds to step S614. In step S614, it is determined that Sheet B is stored on the lower tray 1, and the process proceeds to step S616. On the other hand, in a case where the amount of the reflection light R is less than the third threshold R3 (that is, R<R3), the process proceeds to step S615. In step S615, it is determined that Sheet C is stored on the lower tray 1, and the process then proceeds to step S616.

In step S616, determination is made as to whether the type of sheet designated by the print instruction in step S601 corresponds to the type of sheet on the lower tray 1 which is determined in steps S613 to S615 based on the detection by the sheet sensor 4 in step S608. In a case where the types of the sheets are not determined to correspond to each other, the process proceeds to step S617, the interface (not shown) displays an error message indicating that a wrong type of sheet is stored on the tray, and the operation sequence ends. On the other hand, in a case where the types of the sheets are determined to correspond to each other, it is determined that Sheet 5 is correctly stored on the lower tray 1, and the process proceeds to step S618.

((Performing Printing Operation))

In step S618, printing operation is performed. More specifically, printing operation is performed including sheet feeding in which one sheet out of Sheet 5 is taken out of the lower tray 1 by the pickup roller unit 3, sheet conveyance in which the fed sheet is conveyed via the conveyance roller pair 8, and performing printing on the conveyed sheet by the printing unit 7.

For convenience sake, the above explanation is made about a case where the pickup roller 13 contacts the top surface of the lower tray 1, but the same explanation applies to a case where the pickup roller 13 contacts the top surface of the upper tray 2. In both cases, the presence or absence of the tray is determined in steps S605 to S607, and in a case the tray is present, the state of the sheet on the tray is detected in steps S608 to S615, and based on the results, printing operation is performed.

In the above manner, according to the present embodiment, it is possible, prior to performing printing operation, to detect the states in which no tray is mounted on the printing apparatus body, the remaining amount of the sheets on the tray is zero, and the sheet of a type different from that of a print instruction is stored on the tray. In other words, prior to feeding the sheets stored on the tray by picking them up one by one by the roller, determination is made by a determination unit.

For convenience of explanation, FIG. 4 shows an example of a table used for performing detection of three types of sheets. In this example, the states of the sheet on the tray, which are the presence or absence of the sheet stored on the tray and the type of sheet on the tray, if any, can be detected. It may also be possible, by subdividing the threshold in the range of the amount of the reflection light, to detect more types of sheets, and front and back sides of a sheet, that is, which side of a double-sided sheet is faced up.

((Detection of Remaining Amount of Sheet))

As another example of the states of the sheet on the tray that can be detected in the present embodiment, a method of detecting the remaining amount of sheets stored on the tray will be explained. For convenience sake, the explanation is made about the operation of detecting the remaining amount of Sheet 5 on the lower tray 1, but the same explanation applies to the operation of detecting the remaining amount of Sheet 6 on the upper tray 2.

As stated above, the rotation angle θ_1 from the reference posture of the pickup roller unit 3 at the time when no sheet is stored on the lower tray 1 (the remaining amount of the sheets is zero) is prerecorded in the control substrate. Further, data on the thickness of one sheet per each type of sheet is prerecorded in the control substrate.

Referring to FIG. 6A, in step S605, the rotation angle θ_0 from the reference posture of the pickup roller unit 3 at the time when the pickup roller 13 contacts Sheet 5 on the lower tray 1 is obtained. In this case, an angle displacement amount $(\theta_1-\theta_0)$ from the rotation angle θ_1 is obtained. By referring to the correlation between the obtained angle displacement amount $(\theta_1-\theta_0)$ and the corresponding number of sheets of that type, the remaining amount of the sheets stored on the tray can be obtained by the number of sheets.

The type of the sheet stored on the tray to be used for obtaining the remaining amount of the sheets can be determined by the detection by the sensor as described above (see steps S608 to S615 in FIG. 6B), or the type of sheet designated by a print instruction may be used.

Similarly, the remaining amount of the sheets on the upper tray 2 also can be detected by using the angle displacement amount $(\theta_2-\theta_0)$ from the rotation angle θ_2.

According to the present embodiment, the simple configuration in which the pickup roller unit which is a mechanism for sheet feeding is used enables detection of the presence or absence of the tray and the state of the sheet on the tray at a stage prior to starting the sheet feeding from the tray before performing printing operation, thereby making it possible to prevent poor quality of a print image due to loading a wrong type of sheet or setting a sheet upside down and wasteful printing operation due to sheet supply to the tray being forgotten or the like. Further, since one sensor common to both of the upper and lower trays can detect both the trays, stable detection is enabled due to no influence by sensitivity dispersion among different sensors compared to a case where the two trays in tiers of the upper tray and the lower tray are each provided with a sensor. Furthermore, increase in cost and size of the apparatus can be controlled.

With reference to FIG. 9, a second embodiment of the present invention is explained below. The explanations of the same configurations and effects as those of the first embodiment are omitted and distinctive matters only will be explained.

(Detection of Presence or Absence of Tray)

In the first embodiment, the rotation angle of the pickup roller unit 3 is obtained, and the state of the tray being not set on the printing apparatus body is detected by the fact that the obtained rotation angle is not within the preset range (see steps S605 to S607 of FIG. 6A). The second embodiment is an example of a configuration in which the state in which the lower tray 1 has been removed is detected by detecting the amount of the reflection light by using the sheet sensor 4 and a reflector in combination, instead of the configuration of the first embodiment.

(Configuration of Apparatus)

In an example of a configuration shown in FIG. 9, a reflector 14 is provided lower than the lower tray 1. In a case where

there is no tray between the pickup roller **13** and the reflector **14**, the pickup roller **13** of the pickup roller unit **3** contacts the reflector **14**. Once detection operation is performed by the sheet sensor **4** in a posture in which they contact with each other, the reflector **14** is detected. The detected amount of the reflection light of the reflector **14** is prerecorded in the control substrate.

(Operation Sequence of Apparatus)

An example of an operation sequence (not shown) of the printing apparatus **100** according to the second embodiment will be explained. Once a print instruction is issued, based on the print instruction, control is performed so as to set the upper tray **2** in the first position or the second position. Next, the sheet sensor **4** detects the amount of the reflection light by setting a surface which the pickup roller **13** contacts to be a surface to be detected.

In a case where the detected amount of the reflection light equals the prerecorded amount of the reflection light of the reflector **14**, if control is performed so as to set the upper tray **2** in the first position based on the print instruction, it is determined that the lower tray **1** is removed from the printing apparatus body, and if control is performed so as to set the upper tray **2** in the second position based on the print instruction, it is determined that both of the lower tray **1** and the upper tray **2** are removed from the printing apparatus body.

In a case where it is determined that the tray is removed from the printing apparatus body, the interface (not shown) displays that the designated tray is not mounted and the operation sequence ends.

According to the present embodiment, the steps and configurations in relation to obtaining of the rotation angles in the operation sequence of the printing apparatus according to the first embodiment may be omitted.

With reference to FIGS. **5** to **7**C, a third embodiment according to the present invention will be explained below. The explanations of the same configurations and effects as those of the first embodiment are omitted and distinctive matters only will be explained.

(Detection of Sheet Size)

In the first embodiment, the single sheet sensor **4** detects the states of the sheet such as the presence or absence and type of the sheet on the tray (see FIG. **3** and steps **S608** to **S615** of FIG. **6**B), while in the third embodiment, a group of sheet sensors **12** comprising a plurality of sheet sensors **4** is mounted, whereby the sheet size is detected.

(Configuration of Apparatus)

FIG. **5** is a schematic view of a tip end of the free end of the arm of the pickup roller unit **3** according to the third embodiment as viewed from the pickup roller **13** toward the rotation support unit **9**. In this example, the pickup roller unit **3** has a plurality of sheet sensors **4** disposed near the pickup roller **13** at a predetermined interval in a width direction of a sheet. For convenience of explanation, the pickup roller unit **3** has five sheet sensors **4**.

(Operation Sequence of Apparatus)

FIGS. **7**A to **7**C show an operation sequence from detection of the state of the sheet on the tray to printing operation performed in the printing apparatus **100** according to the third embodiment. The operation sequence according to the third embodiment shown in FIGS. **7**A to **7**C will be explained by focusing on differences from the operation sequence according to the first embodiment shown in FIGS. **6**A and **6**B. Identical or similar reference numerals in the drawings denote identical or similar steps.

In the first embodiment, in step **S606**, in a case where the size relation of the rotation angles satisfies $\theta_0 \leq \theta_1$, the process proceeds to step **S608** in FIG. **6**B and the single sheet sensor **4** performs operation of detecting the top surface of the tray, while in the third embodiment, the process proceeds to step **S701** in FIG. **7**B and the plurality of sheet sensors **4** (five in this example) included in the group of sensors **12** perform the detection operation and the amount of the reflection light Rn (n=1, 2, . . . , 5) detected by each of the sensors is stored in the memory of the control substrate.

Next, in step **S702**, the amounts of the reflection light Rn (n=1, 2, . . . , 5) detected in step **S701** are each compared with the first threshold **R1** defining the range of values of the amount of the reflection light recorded in the table shown in FIG. **4**. A number N which is the number of the sheet sensors **4** in which the detected amount of the reflection light Rn is less than the first threshold **R1** (that is, Rn<**R1**) is obtained and stored in the memory of the control substrate.

Next, in step **S703**, in a case where the number N is zero (that is, N=0 in this example), it is determined that there is no sensor which has detected a sheet, that is, no sheet is stored on the tray, and the process proceeds to step **S712**. In step **S712**, the interface (not shown) displays that the remaining amount of the sheets is zero, and the operation sequence ends. On the other hand, in a case where the number N is not zero (that is, N≤1), the process proceeds to step **S704**.

Further, in step **S704**, in a case where the number N is less than 3 (that is, 1≤N<3), the process proceeds to step **S706** and it is determined that a sheet in size **S1** is stored on the tray, and the process proceeds to step **S709**. On the other hand, in a case where the number N is 3 or higher (that is, 3≤N), the process proceeds to step **S705**.

In step **S705**, further, in a case where the number N is less than 5 (that is, 3≤N<5), the process proceeds to step **S707** and it is determined that a sheet in size **S2** is stored on the tray, and the process proceeds to step **S709**. On the other hand, in a case where the number N is 5 or higher (that is, N=5 in this example due to the maximum number of sensors), the process proceeds to step **S708**. In step **S708**, it is determined that a sheet in size **S3** is stored on the tray, and the process proceeds to step **S709**. In this example, the size relation satisfies the relation of size **S1**<size **S2**<size **S3** represented by using the inequality sign "<."

In step **S709**, determination is made as to whether the sheet size designated by the print instruction in step **S601** corresponds to the size of the sheet on the lower tray **1** which is determined in steps **S706** to **S708** based on the detection by the sheet sensors **4** in step **S701**.

In a case where it is determined that the sheet sizes above do not correspond to each other, the process proceeds to step **S717** in FIG. **7**C, the interface (not shown) displays an error message indicating that a sheet in a wrong size is stored on the tray, and the operation sequence ends. On the other hand, in a case where it is determined that the sheet sizes correspond to each other, it is determined that the sheet in a correct size is stored on the tray, and the process proceeds to step **S610** in FIG. **7**C.

Referring to FIG. **7**C, steps after step **S610** are the same as those in the first embodiment shown in FIG. **6**B. Of the plurality of sheet sensors, with respect to a sheet sensor which has detected a sheet, based on the size relation between the detected amount of the reflection light Rn and the thresholds of the amounts of the reflection light, **R1**, **R2**, and **R3**, the type or front and back sides of the sheet can be determined.

In the third embodiment, since the plurality of sheet sensors **4** are disposed at a predetermined interval in a width direction of the sheet, the size of the sheet in a width direction can be recognized from the number N which is the number of sheet sensors which have detected the presence of the sheet. In this example, for convenience of explanation, the number

of the sheet sensors is set to be five and three types of sheets are detected, but in the present embodiment, the number of the sheet sensors and the sizes of sheets are not limited to the above. By appropriately setting the number of the sheet sensors and the interval, a variety of sheet sizes can be handled.

According to the third embodiment, in addition to the effects of the invention according to the first embodiment, the sheet size can be detected as a state of the sheet on the tray, thereby preventing distortion of print layout or the like due to a mismatch between an image size of print data and the sheet size.

The first embodiment through the third embodiment have been explained using the printing apparatus **100** which is configured such that the sheet feeding unit is provided with two trays in tiers of the upper tray and the lower tray. However, the present invention is applicable to cases having trays in any number, which may be one or a plural number which is three or more. Further, as shown in FIG. **8**, the present invention is applicable to a case where the upper tray and the lower tray are the same in size. That is, the present invention is applicable irrespective of the number of trays and combinations of sizes of trays, as long as it is configured such that the pickup roller unit is provided and the pickup roller can contact the top surface of the tray.

The present invention is applicable to unit apparatuses such as a copying machine, a facsimile, a captured image forming apparatus, and a scanner, as well as a printing apparatus. Further, the present invention is not limited to these unit apparatuses, but is also widely applicable to a sheet feeding apparatus of a complex device having the above in combination or a complex device such as a computer system.

According to the present invention, it is possible to detect a mounting state of the tray on the apparatus body and the states of the sheet on the tray, such as the presence or absence of the sheet, the remaining amount of the sheets, the type of the sheet, the front and back sides of the sheet (which of a double-sided sheet is faced up), and the size of the sheet stored on the tray. However, in the present invention, determination of all of the above is not essential. The present invention encompasses also a form in which any one of the above states is determined.

While the present invention has been described with reference to exemplary embodiments, it is to be understood that the invention is not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.

This application claims the benefit of Japanese Patent Application No. 2014-147835 filed Jul. 18, 2014, which is hereby incorporated by reference wherein in its entirety.

What is claimed is:

1. A sheet feeding apparatus comprising:

a tray storing a sheet and detachably mounted on an apparatus body;

a rotatable arm;

a roller, provided on the arm, configured to pick up the sheet on the tray;

a sensor, provided on the arm, configured to detect a physical property of a surface of the sheet; and

a determination unit configured to determine, based on detection by the sensor, at least any of a mounting state of the tray on the apparatus body and at least one of states of the sheet on the tray selected from the group consisting of the presence or absence of the sheet, a remaining amount of the sheet, a type of the sheet, front and back sides of the sheet, and a size of the sheet stored on the tray.

2. The sheet feeding apparatus according to claim **1**, further comprising a detector configured to detect a state of rotation of the arm, wherein the determination unit performs determination based on detection by the sensor and the detector.

3. The sheet feeding apparatus according to claim **2**, comprising a plurality of the trays, the plurality of the trays including an upper tray and a lower tray,

wherein in response to determination by the determination unit, the roller feeds the sheets stored on any of the upper tray and the lower tray by picking up the sheets one by one.

4. The sheet feeding apparatus according to claim **1**, wherein the sensor is a photoelectric sensor and detects reflection light of a surface on which the roller contacts.

5. The sheet feeding apparatus according to claim **1**, comprising a plurality of the sensors, wherein the plurality of the sensors are disposed along a width direction of the sheet.

6. The sheet feeding apparatus according to claim **1**, further comprising a printing unit configured to perform printing on the sheet,

wherein the determination unit performs determination prior to performing feeding sheets stored on the tray by picking them up one by one by the roller.

7. A sheet feeding apparatus comprising:

an upper tray and a lower tray, each of which stores a sheet, and which are detachably mounted on an apparatus body;

a rotatable arm;

a roller, provided on the arm, configured to pick up the sheet;

a detector configured to detect a state of rotation of the arm; and

a determination unit configured to determine, based on detection by the detector, at least any of mounting states of the upper tray and the lower tray on the apparatus body and at least one of states of the sheet stored on any of the upper tray and the lower tray, the states being presence or absence of the sheet and a remaining amount of the sheet.

8. The sheet feeding apparatus according to claim **7**, wherein the detector has an encoder for detecting a rotation angle of the arm.

9. The sheet feeding apparatus according to claim **7**, further comprising a printing unit configured to perform printing on the sheet,

wherein the determination unit performs determination prior to feeding, to the printing unit, sheets stored on the tray by picking up the sheets one by one by the roller.

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